

# PRECISE DIMENSIONAL MEASUREMENT OF A HELICOPTER MODEL USING GEODETIC AND NON-CONTACT MEASUREMENT TECHNIQUES

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## Abstract

*Industrial measurement requires high precision instrumentation for a good data gathering and analysis. Nowadays, we have offered too much instrumentation from conventional such as robotic total station and non-contact measurement like digital photogrammetry and laser scanning. LEICA TCA2003 robotic total station and TM5100 electronic theodolite is a high precision instrument for the highest requirements in industrial/deformation surveying with the angle and distance measuring accuracies of 0.5" and 1mm respectively. This paper focuses on the industrial observation campaign using geodetic technique and non-contact technique. Non-contact technique refers to photogrammetry and laser scanning. This project is collaboration between Surveying Engineering Research Group Laboratory and Aeronautic Laboratory, Universiti Teknologi Malaysia. The observation object is Eurocopter 350Z Prototype Helicopter Model helicopter.*

## 1.0 INTRODUCTION

Until today, electronic theodolite and total station most commonly used in surveying application. Recent technology with 'robotic' function, total station and electronic theodolite equipped with servo drive mechanism. These mechanisms enable instruments to aim automatically to a point to be measure. The Leica TPS1000 series (The TM5100 and TCA2003) with motorization and automatic targeting selected in this research. TPS1000 system concept contain two unit software namely system software and application software. Using the "workbench" (computer), both units can be loaded across the serial interface by the user. In advance, the Leica TM5100 and TCA2003 attached with automatic target recognition (ATR) which is enable to operate fully manipulated by user.

Implementing of the real time concept in precise measurement is important task in recent day. Dimensional measurement and deformation detection task is very fast and need real-time data gathering and on-site analysis. With latest enhancement in automatic measurement system, it designed specifically for non-contact inspection and for monitoring either indoor or outdoor. With integrated software package, it enables to do non-contact measuring system for the three dimensional determination of coordinate and shape in industry application.

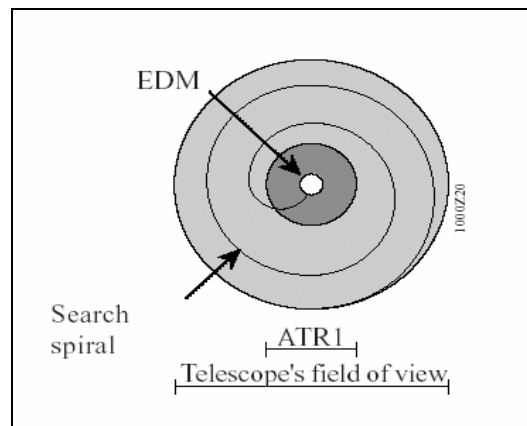
The result shows consistency during the one-hour observation campaign. APSWin has integrated with build-in Automatic Target Recognition (ATR) inside robotic total station. While, ATR function must be activate from robotic total station and COMM and DAQ software module will order the instrument doing the measurement.

## 2.0 GEODETIC MEASUREMENT

Surveying technology allows the determination of 3-dimensional determination and movement. Current technology provides robotic total stations that are able to measure angle with an accuracy of  $\pm 0.5''$  (0.15 mgon) and distance with an accuracy  $\pm 1\text{mm} + \text{ppm}$  in standard measurement mode (Leica Geosystems, 2000).

Actually, TCA2003 produces by Leica Geosystems AG, which designed for conducting deformation-monitoring survey. However, certain researcher has been used this TCA2003 model for industrial measurement such as Dünish & Kuhlman, (2001) and Kuhlmann, (2001), claim tracking moving target is possible with modern tachometry in setting out rail geometry.

Modern technologies are more sophisticated and packaged internally. Certain instrumentations have an active beam sensing capability. With this latest technology, robotic total station allowed the measurement of many points on a surface. Then the points will be monitoring within a short period with the approximate coordinate of each target prism stored in memory or database. All the periodic measurement operation was using Automatic Target Recognition (ATR) technology (Leica Geosystem, 2000).



**Figure 1:** Automatic Target Recognition Concept (Leica Geosystems, 2000)

**Figure 1** show the concept of ATR technology where the telescope center identified to provide precise targeting pointing. The ATR technology takes over the pointing, reading and measuring function completely. Technically, ATR consisted of an external video camera imaging system and a separate servomotor drive (US Army Corp of Engineer, 2002). An emitted IR signal is transmitted to the prism that passively reflects the signal back to the instrument. The return spot is imaged on a high resolution (500x500) pixel CCD camera.

Both applications industrial surveying and deformation analysis require high tech instrumentation and measurement procedure. Industrial surveying commonly referred to:

- limitation on space area to setup a survey network,
- intersection measurement from two station simultaneously,
- real time processing or on-site processing,
- an information of reference network before start the measurement,
- positioning issues,
- special software system to analyzed,
- least square estimations.

That mean, we need a system can be integrated and communicated between instrumentation and workstation (computer) To serve for most automation application of the deformation and industrial measurement, Industrial Deformation Analys (InDA) software system has capability (Halim & Khairulnizam, 2005):

- can treat one, two or three dimensional,
- can perform in single or dual instrumentation,
- have communication module to communicated between user and instrument,
- measured the point automatically either order from user or timer system,
- have database module to handle hundred point,
- have a data processing module for least square estimation, deformation detection and also easy to handle.

The system developed for use on personal computer with the operation system Microsoft Window Me/2000/XP. The software package system installed on a personal computer or notebook it is possible to make all computation and analysis in the field or measurement site.

The main program for InDA are written from combination several programming languages such as in standard Visual C++ based on Microsoft Foundation Classes (MFC) and Microsoft Visual Basic 6. The main InDA are written in standard C/C++ and Visual C++ but several modules are written in standard Visual Basic.

### 3.0 NON CONTACT MEASUREMENT

In this study, Konica Minolta Vivid 910 3D (**Figure 2**) laser scanner have being used as non-contact data acquisition. Vivid 910 is a non-contact 3D digitizer using a laser beam to measure object. This system has capability to record the whole measurement in a snap (about .03 sec (fast mode), 2.5 sec (fine mode) and 0.5 sec (color mode)) (Khairulazhar Zainuddin, et. al., 2008)

The scan data saved in specific format file and transfer to Rapidform2004 software for processing. RapidForm2004 software us used for processing laser scanning data and generate 3D model.

Other method has being used in order to support the measurement is close range photogrammetry.



**Figure 2: Konica Minolta Vivid 910 laser scanner**

### 4.0 REAL OBSERVATION CAMPAIGN

Under collaboration between Surveying Engineering Research Group Lab and Aeronautic Laboratory Universiti Teknologi Malaysia, model of helicopter (**Figure 3**) need to measured and calculated their dimension. The InDA software package is fully used and support the geodetic observation using TCA 2003 and TM5100. InDA software fully operated from automatic data acquisition and on site processing analysis. The observation campaign using TCA2003 and TM5100 with InDA software system determined several point on the body of helicopter model. The result of the measurement compared from manual

measurement using caliper, close range photogrammetry and laser scanning method. **Figure 3** shown helicopter model and geodetic industrial measurement.



**Figure 3 : Helicopter Model & Industrial Measurement Campaign**

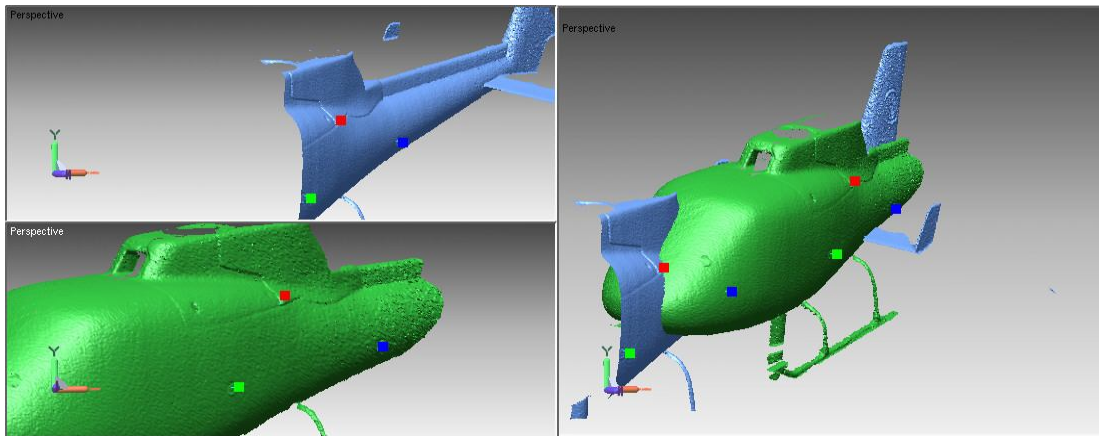
From **Table 1**, several landmark points on the body of helicopter model has selected and measured. The same points used in laser scanning observation and photogrammetry. Several selected point namely with special landmark such as landing gear, air hole, blade, vertical tail and horizontal tail. Several landmarks such as vertical tail, horizontal tail back, landing gear (front) and upper tail boom resulted minimum difference between TM2003/TM5100, laser scanning and photogrammetry. The different in range 1 mm can be achieved between three-measurement methods. For landmark such as landing gear (back) and blade resulted 2 mm – 3mm difference compared to other measurement technique. The reason maybe causes by positional dilution of precision (PDOP). PDOP refer to intersection of target point from observation point (Allan, 1997). **Figure 4** and **5** show laser scanning set up and modeling result processing. Detail explanation about laser scanning concept can be refer to Khairulazhar et. al., (2008).

**Table 1 : Comparison between several instrumentation**

Landmark	TCA2003/TM5100 (mm)	Laser Scanning (mm)	Photogrammetry (mm)
Vertical Tail	221.00	221.086	221.930
Horizontal Tail Back	197.04	196.944	197.600
Landing Gear Front	310	309.691	310.080
Landing Gear Back	312	308.397	307.710
Blade	83.00	80.872	80.600
Upper Tail Boom	453	Not Available	454



**Figure 4 : Laser Scanning set-up**



**Figure 5 : 3D model generated by RapidForm 2004 using laser scanning**

## **6.0 CONCLUSION**

The InDA software system is a fully automated in data acquisition. For data processing and analysis, user still able to process and calculated the final result at field or we called it “on-site solution”

## **7.0 ACKNOWLEDGEMENT**

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